A Comparison of the Performance of Rainbow Options and Stocks under COVID-19 and Ukraine Conflict

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Abstract. This paper hopes to explore which is the better choice for investors under the different environments of the US stock market, rainbow option or buying a single stock. Due to the improvement of the COVID-19 situation in the United States in 2021 and the introduction of government policies to stimulate the economy, the US stock market showed an upward trend throughout 2021. In 2022, due to the conflict between Russia and Ukraine, the global economy will be impacted, and the US stock market is no exception. In these two long-term bear markets and bull markets, it hopes to find a mutation option to control risks and improve returns. In this case, it focuses on rainbow options, which are options that help investors screen out the better-performing stocks or futures included in them. First, this paper paired 14 stocks in five fields, calculated the option's payoff according to the rainbow option's rules, and then compared it with the return of the stock alone to explore the superiority of the rainbow option. The return on the rainbow option is higher than the return on any single stock. Then the option is simulated and priced for 1000 future trading days so as to obtain the return of the rainbow option under the assumption of stable fluctuation in the US stock market environment, which is used as the reference for pricing. Finally, the sensitivity analysis of options is conducted to study the main factors affecting the volatility of option premiums. The result is that the moves in rainbow options are always correlated with the stock that is more active.

Keywords: Rainbow Option, Stock Performance, COVID-19.

1. Introduction

At the beginning of 2020, the COVID-19 pandemic broke out globally, causing a huge shock to the economy and financial markets. Because the virus is highly contagious and fatal, the authorities imposed strict quarantines on their populations and ordered the bulk of business activity to shut down. The US economy is affected most, with the rate of unemployment reaching above 20% [1]. The US stock market has also been severely affected, with sharp declines and fluctuations. However, by 2021, the US stock market gradually showed an upward trend. First, in early 2021, important progress was made in developing and rolling out COVID-19 vaccines. Several pharmaceutical companies announced the development of effective vaccines and began large-scale vaccination programs. COVID-19 intranasal (IN) vaccines are also being developed that have shown promising ability to induce a significant amount of antibody-mediated immune [2]. That has provided hope for the market, as investors have become optimistic about the outlook for economic recovery and corporate earnings. The launch of vaccines has boosted confidence in economic activity and boosted investors' appetite for risk. Second, the Federal Reserve and the government adopted a series of stimulus measures to balance the epidemic's economic impact. Unprecedented non-pharmaceutical interventions targeted to curb the spread of COVID-19 dramatically impacted the global economy and financial markets [3]. The Federal Reserve System has adopted an accommodative monetary policy, keeping interest rates low and engaging in a large-scale asset purchase program to provide liquidity support and stabilize financial markets. These stimulus measures have boosted market confidence and contributed to the stock market rally. The combination of vaccine promotion and stimulus measures led to a gradual economic recovery. Enterprises and industries began to gradually return to normal operations, and profitability improved. That further bolstered investors' expectations of an economic recovery, driving stocks higher.

The outbreak of the conflict between Russia and Ukraine has triggered global investor concerns and market uncertainty. This has led to a severe decline in US stocks. The Russia-Ukraine conflict is

a geopolitical crisis involving the security and stability of two important regions. European equities and Russian bonds are the net transmitters of shocks [4]. Investors are worried about the escalation of the conflict and the possible spread of regional conflict, which will cause the US stock market to decline. The conflict between Russia and Ukraine triggered a chain reaction in global markets. The stock market is global, with international investors moving money between different markets. Using daily data on stock returns for a sample of 94 countries over the period from 22 January 2022 to 24 March 2022, the results show significant negative effects of the Ukraine–Russia war on global stock indices [5]. When there is conflict and uncertainty in a region, investors tend to withdraw from risky assets and seek safety. The sentiment spread around the world and led to declines in several stock markets, including the U.S. stock market.

The recent Palestinian-Israeli conflict and the Russia-Ukraine conflict both occurred in the Middle East, which is one of the main reserves of fossil energy in the world. Such disputes are bound to cause changes in world energy prices. investors diversifying their portfolios should consider dynamic volatility and crude oil-stock price correlations to maximize returns and decrease risk [6]. The rainbow option is a good way to control the risk. The rainbow option is an options contract linked to the performances of two or more underlying assets. They can speculate on the best performer in the group or the minimum performances of all the underlying assets at one time [7]. So how does the option work? In other words, what's the definition of a bad performer?

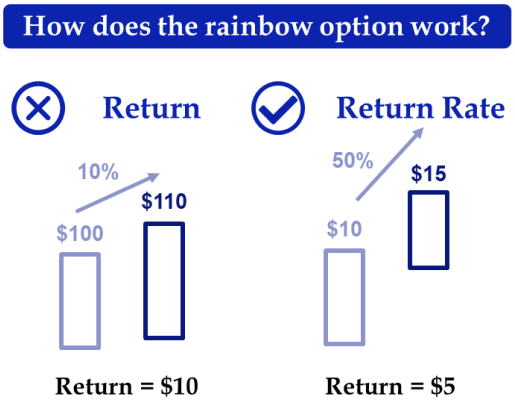


Figure 1. Rules of rainbow option

Even though the left has a higher return figure, the option will still exercise based on the right one, which has a higher return rate, so the percentage of return is the only principle the option should follow (see Figure 1). A very popular approach to pricing Arithmetic Asian options is the Monte Carlo simulation. Rainbow options have been priced in many different ways. The so-called control variate technique is a very common method to enhance its accuracy [8]. Now, there are two special stocks. The stock price is quite stable every year. Its return rate is ten percent. The application of rainbow options is very broad. It can be converted between multiple assets and valuation and investment operations. In a practical application, a real option model has been used to value a fertilizer plant that has flexibility in selling ammonia and urea [9].

2. Methodology

2.1. Data Selection

In order to make my comparison more diversified, this paper selected 14 stocks from American stocks, which are highly representative in their respective fields. Meanwhile, this paper divided them into four types of stocks for exploration according to their industry types: technology stocks, medical stocks, consumer stocks, energy stocks and financial stocks. Technology stocks include apple, Microsoft, TSMC, Google, Amazon, HP; healthcare stocks include Johnson & Johnson, consumer stocks include Target, Costco, Starbucks, Disney, Netflix, energy stocks include ExxonMobil, and financial stocks include Citibank, Bank of America Corporation. According to the rules of the

rainbow option, this paper decided to group them in pairs to form two stocks in the rainbow option. For tech stocks, here this paper pairs two stocks that appear highly correlated to ensure that their values are similar in share price and volatility. In addition, for example, this paper pairs APPLE and TSMC not only because the trend of their stock price fluctuations is similar but also because TSMC is the upstream enterprise of APPLE, and their main product, chip, is an important component of APPLE's devices.

In 2021, the US stock market showed a significant upward trend (here it judges according to the rise and fall of the Nasdaq index), that is, a bull market, and in 2022 due to various reasons such as the Russia-Ukraine conflict, the overall decline of the US stock market is very serious. In order to explore the performance of rainbow options in the time dimension, this paper choose 2021-2022 to observe stocks in 2020-2021. Due to the special events in 2022 and 2021, there are two sectors of the industry that always have a different performance from the general trend of the US stock market, respectively, medical stocks and energy stocks. They are still rising in the return of the global epidemic in 2022 and the Russia-Ukraine conflict, so this paper put them in a group to explore.

Finally, the rainbow options are grouped as follows: APPLE& TSMC, Microsoft & HP, Google & Amazon, Johnson & Johnson & ExxonMobil, Target & Costco, Starbucks & Disney, Citibank & Bank of America Corporation.

2.2. Superiority Analysis of Rainbow Options

The discussion of the advantages of rainbow options is mainly about the stock return, that is, how much additional return you can get from using rainbow options compared to buying any single stock in the rainbow options. This paper assumes that the strike price is \$100, so the return can be calculated as $S_1/S_0 \times 100$, where s1 and s0 are the stock prices of the day and the day before, respectively. Therefore, this paper chose stocks with higher returns to execute according to the rules and finally calculate the average payoff. At the same time, calculate the average payoff of each individual stock for a whole year, and finally, compare and draw a conclusion.

2.3. Simulation Pricing of Rainbow Options

From the rules of rainbow option set by me, it is easy to find that this option will definitely have excellent returns. It can not only give the buyer the maximum return when the stock market rises, but also stop the loss timely when the stock market falls. It can be based on the investor's very high return and investment opportunities. Even investors can put a number of their own positive or even not good stocks into the option, it can also obtain considerable returns. Thus, the pricing of options with so many advantages can also be a big problem. This paper simulated each rainbow option in 1000 trading days in the future, and carried out volatility analysis and simulated pricing. This paper selected the group of stocks with the best performance of the rainbow option to simulate pricing analysis which is AAPL&TSM. Firstly, this paper has to determine all the parameters of the simulated option in Table 1, this paper use the real risk-free rates in the US financial markets as r, uses annual volatility as sigma, makes the stock price on Dec30, 2022, as the S_0. This paper use 1devided by 252 as T. Besides. this paper searched that the real delta of companies is 0, so here this paper set the delta to 0. This paper assumes the strike price is 100\$.

Table 1. Parameters of simulation of rainbow option

	AAPL	TSM
r	0.022	0.022
sigma	0.2501	0.3294
S0	129.378	73.63688
T	0.0039683	0.0039683
delta	0	0
strike price	100	100

Secondly, this paper generated a random array of a normal distribution which is the Z-values of AAPL for the next 1000 days, and the z-values of TSM are calculated from the correlation between two stocks and the z-values of AAPL. Since all the parameters are obtained, this paper can value the option price in the future of AAPL and TSM according to the BSM formula [10].

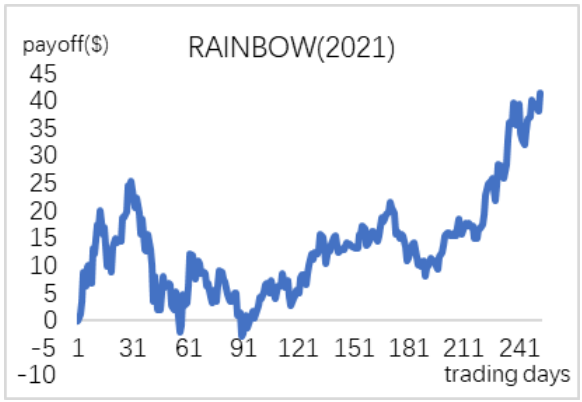
$$S_{T=}e^{\left(\alpha-\frac{1}{2}\sigma^2\right)T+Z\sigma\sqrt{T}}S_0. \quad (1)$$

Thirdly, this paper calculated the rate of return of the two stocks. Since the stock market is assumed to be in a dynamic equilibrium state during the simulation, that is, the stock market will not fluctuate significantly in the next 1000 trading days. To better simulate the pricing, it hopes the returns of rainbow options are positive. This paper chose the maximum of return rate of AAPL, TSM, and 0 to calculate the payoff because this paper wants all the payoff to be positive. Then, this paper made a 3D graph to demonstrate the relationship between the payoff and two option prices. Finally, this paper conducts a sensitivity analysis of the options model to explore the price changes of simulated priced options in the case of changing stock prices, correlations, and volatility.

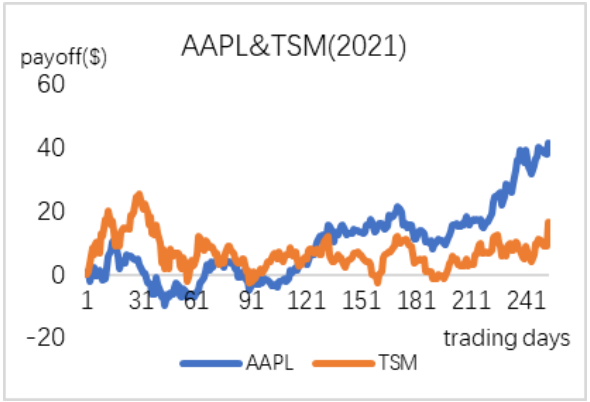
3. Results

3.1. The Superiority Analysis of Rainbow Option

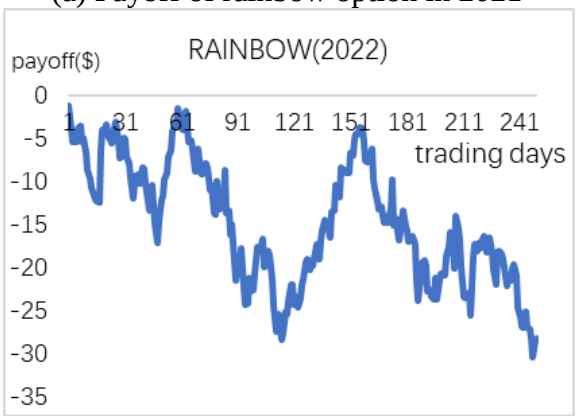
Adopting the methods above, this paper uses examples of rainbow option performance from Apple & TSMC to generate two sets of comparison images (see Figure 2). It can be seen that the payoff curve of the rainbow option can always be at the highest value of the two curves. In this case, this rainbow option has extremely high superiority. Regardless of the overall performance of the U.S. stock market, rainbow options will always yield better returns than any other stock; In the bear market, it can help investors reduce their losses, and in the bull market, it can make investors more money.



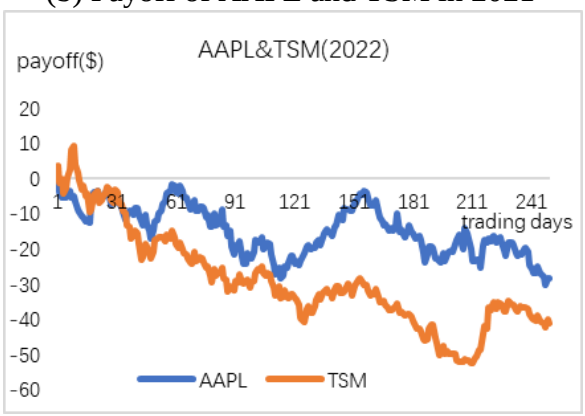
(a) Payoff of rainbow option in 2021



(b) Payoff of AAPL and TSM in 2021



(c) Payoff of rainbow option in 2021



(d) Payoff of AAPL and TSM in 2021

Figure 2. Comparison of rainbow option and stock performance

In addition, since this paper has several anomalous stocks and several groups of stocks that are not highly correlated, including the volatility of the US stock market, this paper has tabulated the average returns of seven groups of stocks to explore the generality of the above advantages.

3.2. Results of the Simulation

Table 2. The average payoff of technology stocks and rainbow option

	AAPL	TSM	rainbow option
2021	9.4112	6.9512	13.43479071
2022	-14.8000347	-29.18020724	-14.8000347
	GOOL	AMZ	rainbow option
2021	43.85471898	4.916120399	43.85548276
2022	-21.01610942	-26.20234436	-21.0161094
	MSFT	HPQ	rainbow option
2021	27.35470374	27.12030215	33.94936238
2022	-19.47640261	-12.38493299	-12.1483435

Table 3. the average payoff of Healthcare and Energy stocks and rainbow option

	CVX	JNJ	rainbow option
2021	26.42655875	7.015892469	26.48857801
2022	36.16142553	1.874311249	36.16142553

Table 4. The average payoff of consumer stocks and rainbow option

	STUB	DIS	rainbow option
2021	9.591790435	-1.050631268	10.19650213
2022	-24.16037267	-27.22282342	-24.1603727
TGT	CST	rainbow option	TGT
27.74187796	11.24935084	29.00852908	27.74187796
-21.45395211	-9.727470458	-9.72747046	-21.45395211

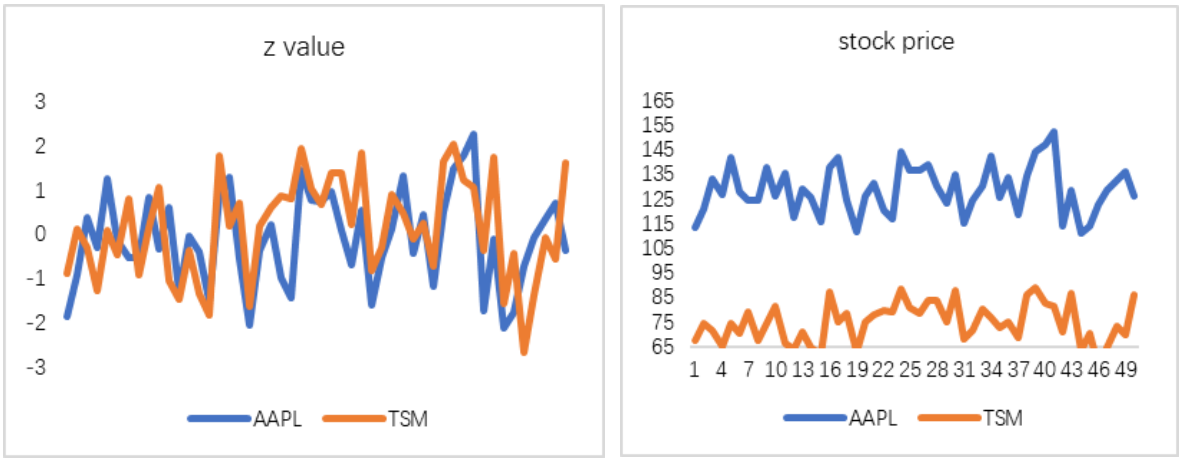
Table 5. The average payoff of financial stocks and rainbow option

	BAC	C	rainbow option
2021	35.74069185	17.10018211	35.76393751
2022	-18.83205046	-16.77693442	-18.8320505

Form Table 2 to Table 5, it can be seen that regardless of any period in any field, rainbow options always have certain advantages to assist stock holders to make better investments3.2.2 simulation of payoff.

3.3. Simulation Pricing and Sensitivity Analysis of Rainbow Options

This paper generated a random array of normally distribution which is Z-values of AAPL for the next 1000 days, and z-values of TSM is calculated from the correlation between two stocks and the z-values of AAPL (see Figure 3).



(a) Z-value (b) Stock Price

Figure 3. An example of the Z-value and stock price simulation for the first 50 days

Then, this paper calculated the rate of return of the two stocks. Since the stock market is assumed to be in a dynamic equilibrium state during the simulation, the stock market will not fluctuate significantly in the next 1000 trading days. To better simulate the pricing, it hopes the returns of rainbow options are positive. This paper chose the maximum of return rate of AAPL, TSM, and 0 to calculate the payoff because it wants all the payoff to be positive. Then, this paper made a 3D graph to demonstrate the relationship between the payoff and two option prices (see Figure 4).

$$V(S_1, S_2, T) = MAX(MAX(AAPL^*, TSM^*)-X, 0)$$

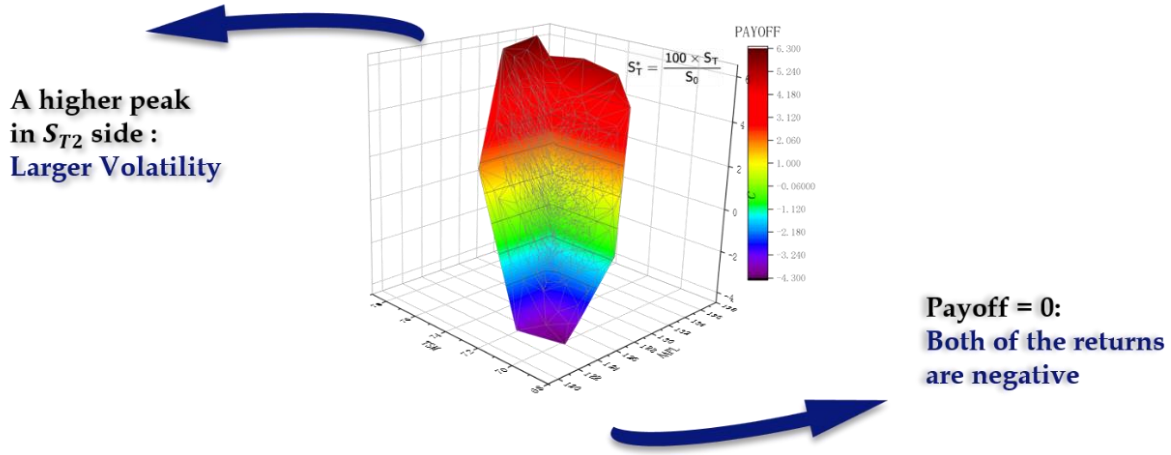


Figure 4. 3D graph of payoff and prices of tow stocks

The option holder has the right to choose the best-performing stock at the contract's expiration date. In this function, the strike price X of AAPL or TSM is 100, set a new variable S_T^* equals to 100 times S_T over Spot price S_0, which means if this paper gets a return of 5% in simulation, the S_T^* will be 105. The rainbow plot shows a higher peak in the AAPL side because AAPL is more volatile. And in the bottom area, payoff = 0 because both of the returns are negative. It is also a common strategy to price options using the average payoff, which is discounted already generated here.

Finally, this paper conducts a sensitivity analysis of options model to explore the price changes of simulated priced options in the case of changing stock prices, correlations, and volatility. In the sensitivity analysis, there is a negative correlation between the correlation rate of 2 stocks and the option premium (see Figure 5). If buyers want to hedge, they could choose negatively-correlated stocks in different industries. If buyers have expectations in an industry, choose positive-correlated stocks to get a higher return. In addition, there is a positive correlation between volatility and option premiums. The riskier the stock is, the higher return buyers will get.

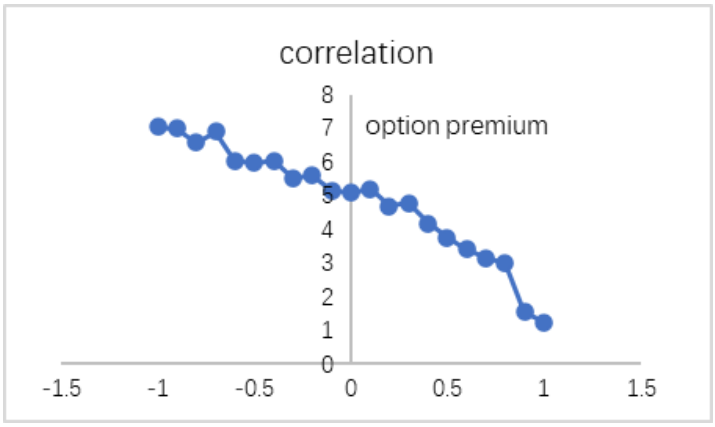
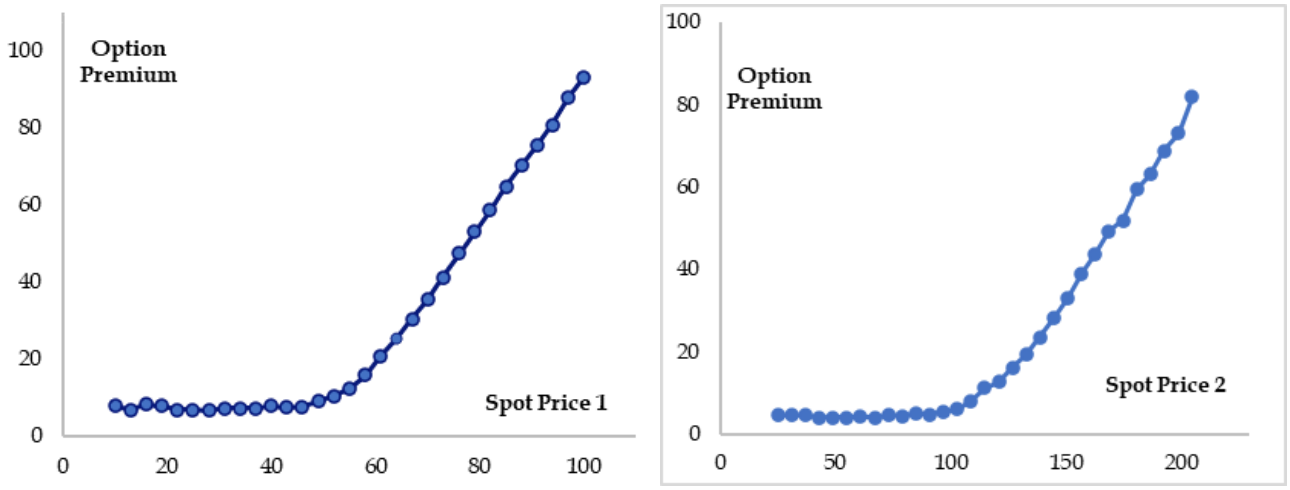


Figure 5. The relationship between option premium and correlation

As for the stock price, it can be seen that the relationship consists of 2 lines with different slopes (see Figure 6). Having done a process of AVERAGE, the disappears in the payoff function. So, the volatility in the horizontal line is caused by asset 2.



(a) Spot price 1 (b) Spot price 2

Figure 6. The change of the option premium with the spot price

The rainbow option behaves quite like a standard European option on asset 2 (see Figure 7). Once ST1 drops a lot, the return depends on the second asset. The rainbow option behaves quite like a standard European option on asset 2.

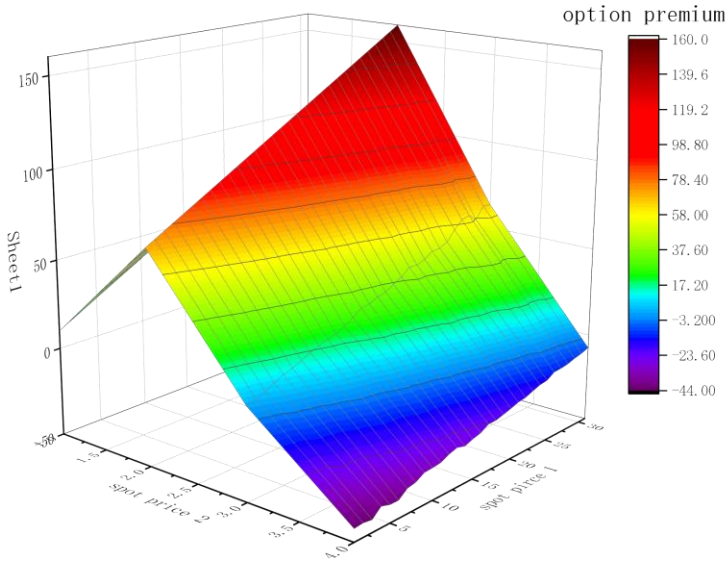


Figure 7. The relationship between option premium and spot price

4. Conclusion

In conclusion, as a multi-asset option, the rainbow option has the potential for risk control and desirable leverage. Not only can it give investors the most profit during periods of high volatility, but, as the name suggests, rainbow options can always provide the most profitable solution for any number of stocks, regardless of their correlation. If investors have a strong expectation in an industry but don't know which stock will get a higher return, then the rainbow option is the best choice. The world situation has always been in a state of fluctuation.

However, there are still great limitations in this study. First, the selection of stocks. Although 14 stocks can represent the changes in stock markets in various fields to a certain extent, the number is still too small to represent the changes in the entire US stock market. So there are certain disadvantages in the analysis; As for pricing, the rainbow option has more official and academic options pricing methods involving ITO lemma and solving partial differential equations. Therefore, the simulated pricing in this paper can only be used as the method under the ideal volatility of the US stock market. In reality, stocks change all the time, so such pricing is not suitable. At the same time, the content of rainbow options is not only stocks but also futures and options, and this paper only discusses the situation of two stocks, which has some limitations.

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